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Abstract: Silica-based fibers doped with $LaF_3:Tm^{3+}$ nanoparticles, prepared by MCVD and solution doping exhibited a fluorescence lifetime of 55 µs at 810 and 1470 nm, with background losses below 0.1 dB/m at 1300 nm.

OCIS codes: (060.2270) Fiber characterization; (060.2290) Fiber materials; (160.4236) Nanomaterials; (160.5690) Rare-earth-doped materials; (160.6030) Silica.

1. Introduction

Lasers and amplifiers based on rare-earth (RE)-doped silica optical fibers are of great interest for many applications. However, silica glass as a host for RE imposes some limitations to the development of devices having improved spectroscopic performances : gain curve engineering, photodarkening, spectral coverage, etc. For the latter application, the case of thulium ion (Tm^{3+}) is typical: the high-phonon energy of silica prevents the implementation of interesting optical transitions of Tm^{3+} ions at 0.8 and 1.47 µm, because fast non-radiative decay (NRD) from the $^3H_4$ metastable level to the $^3H_5$ level prevents population inversion. Hence, the resulting $^3H_4$-lifetime in silica and LaF_3 are measured at 14 µs and 2 ms [1], respectively. To mitigate NRD, a route of interest consists of embedding the RE ions within nanoparticles of composition and structure different from those of silica. That would provide a beneficial local environment to RE ions in terms of spectroscopic properties [2], like diminishing the effective host phonon-energy. In this work we study the properties of silica-based, MCVD-prepared fibers using $LaF_3:Tm^{3+}$ (1 mol %) nanoparticles as the RE carrier during the fabrication process. The 10-20 nm diameter nanoparticles were produced by precipitation methods [3], suspended in ethanol and were incorporated by solution doping into the core of a preform made using MCVD [4]. Porous layer densification, preform collapsing and fiber drawing were performed conventionally. Importantly, no post-process heat treatment was applied on the fiber.

2. Results

Through SEM analyses on preform and fiber, nanodomains of average size 10-20 nm (SEM resolution limited) were observed across the core. The fiber background losses was less than 0.1 dB/m at 1300 nm. The first e-folding time of the 810-nm emission band ($^3H_4$ level) was 55 µs under 785-nm excitation. Although it is much less than that in bulk LaF_3, it is 4 to 5 times larger than that reported in pure silica, close to that reported in alumino-silicate fibers with 9 mol% of Al_2O_3 [5]. Here only 1 % of LaF_3 addition, on average, to the fiber core suffice to obtain the same spectroscopic alteration. Further spectroscopic and material characterizations are under progress to interprete theses results and assess the potential of this type of fiber for future applications.

3. References

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